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A neoclassical interpretation of momentum

Laura Xiaolei Liu [a,b,1], Lu Zhang [c,d,*]

[a] School of Business and Management, Hong Kong University of Science and Technology, Hong Kong
[b] Guanghua School of Management, Peking University, China
[c] Fisher College of Business, The Ohio State University, 760A Fisher Hall, 2100 Neil Avenue, Columbus, OH 43210, United States
[d] National Bureau of Economic Research, United States

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ABSTRACT

The neoclassical theory of investment implies that expected stock returns are tied with the expected marginal benefit of investment divided by the marginal cost of investment. Winners have higher expected growth and expected marginal productivity (two major components of the marginal benefit of investment), and earn higher expected stock returns than losers. The investment model succeeds in capturing average momentum profits, reversal of momentum in long horizons, long-run risks in momentum, and the interaction of momentum with several firm characteristics. However, the model fails to reproduce the procyclicality of momentum as well as its negative interaction with book-to-market equity.

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1. Introduction

Momentum is a major anomaly in financial economics and accounting. Bernard and Thomas (1989) document that stocks with high earnings surprises earn higher average returns over the next twelve months than stocks with low earnings surprises (earnings momentum), and conclude that their evidence "cannot plausibly be reconciled with arguments built on risk mismeasurement but is consistent with a delayed price response (p. 34)."[2] Jegadeesh and Titman (1993) document that stocks with high recent performance continue to earn higher average returns over the next three to twelve months than stocks with low recent performance (price momentum), and suggest that "the market underreacts to information about the short-term prospects of firms (p. 90)."[3] The bulk of the momentum literature has adopted the behavioral interpretation.

* Corresponding author at: Fisher College of Business, The Ohio State University, 760A Fisher Hall, 2100 Neil Avenue, Columbus, OH 43210, United States. Tel.: +1 614 292 8644; fax: +1 614 292 7062.
E-mail addresses: fnliu@ust.hk (L.X. Liu), zhanglu@fisher.osu.edu (L. Zhang).
[1] Tel.: +852 2358 7661; fax: +852 2358 1749.

[2] A voluminous empirical literature documents earnings momentum, which is also referred to as post-earnings announcement drift in the accounting literature. Ball and Brown (1968) first observe the drift. Many subsequent studies have documented this anomaly more precisely in different samples and explored different explanations (e.g., Foster et al., 1984; Bernard and Thomas, 1990; Chan et al., 1996).

[3] Many subsequent studies have confirmed and refined price momentum. Asness (1997) shows that momentum is stronger in growth firms than in value firms. Rouwenhorst (1998), Hou et al. (2011), and Fama and French (2012) document momentum profits in international markets. Moskowitz and Grinblatt (1999) report large momentum profits in industry portfolios. Several studies document interactions of momentum with characteristics such as size, analyst coverage, trading volume, firm age, stock return volatility, and credit ratings (e.g., Hong et al., 2000; Lee and Swaminathan, 2000; Jiang et al., 2005; Zhang, 2006; Avramov et al., 2007). Jegadeesh and Titman (2001) show that momentum remains large in the post-1993 sample. Finally, Asness et al. (2013) report consistent value and momentum profits across eight diverse markets and asset classes including country equity index futures, government bonds, currencies, and commodity futures.

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In particular, Barberis et al. (1998), Daniel et al. (1998), and Hong and Stein (1999) have constructed behavioral models to explain momentum using conservatism, self-attributive overconfidence, and slow information diffusion, respectively.

As a fundamental departure from the existing literature, this paper uses the neoclassical theory of investment to examine whether momentum is correctly connected to economic fundamentals through the first principles of firms. The answer is, perhaps surprisingly, affirmative. Under constant returns to scale, the stock return equals the (levered) investment return. The investment return, defined as the next-period marginal benefit of investment divided by the current-period marginal cost of investment, is tied with firm characteristics via the first principles. Intuitively, winners have higher expected growth and higher expected profitability, which are two major components of the expected marginal benefit of investment. As such, winners earn higher expected stock returns than losers.

The structural model is estimated via generalized method of moments (GMM) by matching average levered investment returns to average stock returns across momentum portfolios. For price momentum, the winner-minus-loser decile has a small model error (alpha) of 0.40% per annum, which is only 2.65% of the average winner-minus-loser return of 15.09%. Also, the mean absolute error across the deciles is 0.83%, which is 6.69% of the average decile return of 12.40%. For earnings momentum, the winner-minus-loser decile has an alpha of −0.92%, which is 10.86% of the average winner-minus-loser return of 8.47%. The mean absolute error across the deciles is 0.63%, which is only 4.12% of the average decile return of 15.26%. The expected investment-to-capital growth is the most important component of momentum. Without its cross-sectional variation, the winner-minus-loser alpha jumps from 0.40% in the benchmark estimation to 9.92% for price momentum, and from −0.92% to 4.07% for earnings momentum.

The investment model is also consistent with the short-lived nature of momentum. In particular, the price momentum winner-minus-loser decile in the data starts at 19.98% per annum in the first month after the portfolio formation, falls to 13.15% in month six, converges to zero in month ten, and turns negative afterward. Similarly, the winner-minus-loser return in the model starts at 18.21% in the first month, falls to 10.73% in month six, converges to zero in month fifteen, and turns negative afterward. In addition, the low persistence of the expected investment-to-capital growth is the underlying force of this reversal. The expected growth spread between winners and losers starts at 39.45% in month one, drops to 23.06% in month six, converges to zero in month thirteen, and turns negative afterward. In contrast, the profitability spread between winners and losers is much more persistent.

The investment model goes a long way toward fitting the average returns across two-way portfolios from interacting momentum with firm characteristics such as size, age, trading volume, credit ratings, and stock return volatility. Although occasionally large, the investment alphas do not vary systematically with either price or earnings momentum. However, the model fails to capture the negative interaction between momentum and book-to-market. The winner-minus-loser alphas for price momentum across the low, median, and high book-to-market terciles are 3.46%, −0.70%, and −6.80% per annum, respectively, which vary inversely with book-to-market. More important, the high-minus-low alphas across the loser, median, and winner price momentum terciles are 11%, 10.07%, and 0.73% per annum, respectively, which vary strongly with momentum. In addition, contrary to Cooper et al. (2004), momentum in the model is not higher following up than down markets. Finally, the investment returns across the price momentum deciles display long-run risks similar to the stock returns in Bansal et al. (2005).

Cochrane (1991) uses the investment model to study aggregate asset prices. Belo (2010) uses the marginal rate of transformation as a stochastic discount factor. Jermann (2010, 2013) uses the investment model to study the equity premium and the term structure of interest rates. Berk et al. (1999), Johnson (2002), Sagi and Seasholes (2007), and Li (2014) construct dynamic investment models to account for momentum quantitatively. Our work differs by doing structural estimation on closed-form investment return equations with real data. Built on Liu et al. (2009), our work differs by focusing on momentum. It also contains a more polished timing alignment procedure that allows us to construct monthly investment returns out of annual accounting data to match with monthly stock returns. This methodological innovation increases the power of our tests substantially.

The rest of the paper unfolds as follows. Section 1 sets up the model. Section 2 describes our econometric design. Section 3 presents our estimation results. Section 4 concludes.

2. The investment model

Firms use capital and costlessly adjustable inputs to produce a homogeneous output. These inputs are chosen each period to maximize operating profits, defined as revenue minus the expenditure on these inputs. Taking operating profits as given, firms choose investment to maximize the market value of equity.

Let $\Pi(K_{it}, X_{it})$ denote the operating profits of firm i at time t, in which K_{it} is capital, and X_{it} is a vector of exogenous aggregate and firm-specific shocks. $\Pi(K_{it}, X_{it})$ exhibits constant returns to scale, i.e., $\Pi(K_{it}, X_{it}) = K_{it}\partial\Pi(K_{it}, X_{it})/\partial K_{it}$. In addition, firms have a Cobb–Douglas production function, meaning that the marginal product of capital is $\partial\Pi(K_{it}, X_{it})/\partial K_{it} = \kappa Y_{it}/K_{it}$, in which $\kappa > 0$ is the capital's share in output, and Y_{it} is sales. Capital evolves as $K_{it+1} = I_{it} + (1-\delta_{it})K_{it}$, in which δ_{it} is the exogenous proportional rate of capital depreciation and is firm-specific and time-varying. Firms incur adjustment costs when investing. The adjustment cost function, denoted $\Phi(I_{it}, K_{it})$, is increasing and convex in I_{it}, decreasing in K_{it}, and of constant returns to scale in I_{it} and K_{it}. Specifically, it has a quadratic form: $\Phi(I_{it}, K_{it}) = (a/2)\,(I_{it}/K_{it})^2 K_{it}$, in which $a > 0$.